BONUS INSPIRE publishable summary, second project period

Brief description of the project

Process-based understanding of changes in spatial distributions of cod, herring, sprat and flounder, and disentangling the role of natural drivers and various human induced impacts constitute the challenging topic for the research in BONUS INSPIRE. The project sets out to fill in the most persistent gaps in knowledge of the spatial ecology of the major commercial fish and thereby support the effectiveness of the relevant policies and ecosystem-based management of the Baltic Sea. BONUS INSPIRE is designed to substantially advance our knowledge on the four major commercial fish species in the Baltic Sea. These fish form more than 95% of the commercial catches, and represent key elements of the Baltic Sea ecosystems.

Work performed

✓ Data collections:
   a. Completing extensive gillnet and beach seine surveys to monitor the distribution of the main life stages of cod and flounder at pan-Baltic scale;
   b. Finishing hydro-acoustic and experimental trawling surveys to obtain additional information on distribution and abundance of adult and juvenile herring and sprat;
   c. Completing surveys on distribution of eggs and larvae in the open Baltic Sea to investigate the importance of northern Baltic Proper as a reproduction area for sprat;
   d. Investigating vital parameters of the egg and spermatozoa characteristics to reveal spatial distribution of flounder ecotypes in various parts of the Baltic Sea;
   e. Continuing assembling historical data (e.g., zooplankton, tagging information, electronic data storage tags, larval herring and cod, fish stomach content data, acoustic survey data and international trawl survey data) into a common databases for further analyses.

✓ Modeling applications:
   a. Hydrodynamic model combined with a Lagrangian particle tracking technique to provide long-term knowledge of environmentally-related survival probability and drift of eastern Baltic cod eggs and yolk-sac larvae;
   b. Shape analysis of archived otolith, and the impact of "Eastern" cod's immigration on recruitment by hydrographic drift modeling to analyse the spatio-temporal dynamics of stock mixing;
   c. Assessment of the eastern Baltic cod stock with two models, in which natural mortality in recent years was allowed to increase (or be dependent on weight of cod, which drastically declined in recent years);
   d. Trial assessments of herring sub-stocks separated on biological grounds from the Central Baltic herring.

✓ Collaborations and impact:
   a. Close collaboration with ICES and the Baltic Sea Advisory Commission;
   b. Organising and co-convening ICES ASC Theme Session 'From genes to ecosystems: spatial heterogeneity and temporal dynamics of the Baltic Sea' with BONUS BIO-C3 and BAMBI;
   c. Contributing to BONUS 2016 summer school (with BONUS BIO-C3 and BAMBI projects);
   d. Continuous delivery of project news to BONUS projects website, active blogging and real-time display of information (incl. on publications, meta-databases and image galleries) on the project website.

Main results

Spatial distributions

- ✓ As both coastal- and deep sea spawning flounder ecotypes occurred in ICES subdivisions (SD) 25 and 28, and spawning individuals of the coastal spawning ecotype occurred also at 65-80 m depth in SD 28 it is suggested that <u>flounder population mixing with hybridisation may occur</u>.
- ✓ Spatio-temporal analyses of cod distribution from pelagic and bottom-trawl surveys evidenced the diel vertical migration at the population level and the <u>importance of density-dependence in adult cod distribution</u>.
- ✓ A Bayesian network model indicated that <u>habitat type plays a very important role in cod distribution</u>, and that the interplay to other environmental conditions is non-stationary temporally and spatially.
- ✓ Studies on <u>feeding ecology of the Gulf of Riga spring herring</u> showed that the entrance of the Gulf is the area with worst herring feeding conditions as evidenced by the highest values of empty stomachs and lower values of feeding intensity.

Passive movements, active migrations and habitat connectivity

- ✓ Egg buoyancy in relation to topographic features like bottom sills and strong bottom slopes could appear as a <u>barrier for transport of the Baltic cod eggs</u> and could potentially limit the connectivity of cod early life history stages between the different basins in the central and eastern Baltic Sea.
- ✓ The <u>percentage of "Eastern" Baltic cod in the Arkona Basin increased from ca. 20 % before 2005 to > 60 %</u> in recent years. For longer distances than between adjacent basins, tag-recapture data-points indicate that <u>cod in general do not perform long-distance migrations</u>, but that only a small fraction (<10%) of the tagged population is conducting trans-basin migrations. Thus, adult migrations probably do not contribute to whole Baltic scale re-distributions of cod. Furthermore, it implies that <u>regional stock recovery might not lead to recovery of cod in the whole Baltic Sea</u>, but rather to regional regulation of stock size due to density-dependent processes.

Scaling from individuals to populations

- ✓ In the short-term perspective, the Gulf of Riga <u>spring herring recruitment</u> abundance <u>is significantly determined by the number of large larvae</u> originating from the shallow and sheltered coastal areas. The abundance of large larvae was, in turn, influenced not by food availability, but by water temperature only.
- ✓ Development of distribution probability maps of juvenile cod and flounder.

Stock assessments

- ✓ Addressing the severe difficulties related to providing analytical assessment for the eastern Baltic cod stock: the assessment models with natural mortality showing increasing trend perform much better than the standard assessment models in which mortality is assumed constant. Obtained results strongly suggest that <u>natural mortality of cod has markedly increased in recent years</u>.
- ✓ The trial assessments of herring sub-stocks in the Central Baltic showed that <u>fishing mortality in these herring sub-stocks may be significantly higher</u> than for the presently used assessment unit of the Central Baltic Sea.
- ✓ <u>Sub-populations may exist within the deep sea spawning (with pelagic eggs) flounder ecotype</u>; one in SD 24 and SD 25, one in SD 26 and SD 28 separated from fish in the Belt-Sea area (SD 22 and SD 23). No difference in viable hatch or in larval growth up to yolk sac depletion between hybrid and non-hybrid flounder indicates that <u>hybrid flounders may occur in areas where both ecotypes occur</u>.

Ecosystem based assessment and project impact

- ✓ Start critical revision of the existing management for cod, herring and sprat.
- ✓ Identifying focus and designing strategy of the high-profile paper as the key-result of the project.
- ✓ Project members participations in >100 stakeholder committees during the second project year.